managers may feel that the differences in performance of the different strains after release in lakes or streams have been exaggerated.

The Hatchery Operations Committee, consisting of the supervisors of regional fish hatcheries, the Fish Hatchery Manager II in Region 3, and the Hatchery coordinator in the Inland Fisheries Division, formulate plans for the State's rainbow trout program with input from the Broodstock Committee, the fisheries management supervisors, and Graham Gall.

Some items the Hatchery Operations Committee is addressing are:

(i) The problem of gill bleeding in the RTH.

(ii) Possible replacements for RTH broodstock.

(iii) The lack of eyed eggs available in early summer and late fall.

(iv) The need for maintaining duplicate sets of broodstock.

(v) The planting of catchable fish by pounds rather than numbers.

(vi) The move toward larger size catchables (2/lb rather than 4 to 6/lb).

(vii) The pressure from private growers to sell rainbow trout to the State.

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EVALUATION OF WILDLIFE-HABITAT RELATIONSHIPS DATA BASE FOR PREDICTING BIRD COMMUNITY COMPOSITION IN CENTRAL CALIFORNIA CHAPARRAL AND BLUE OAK WOODLANDS [1]

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The California Wildlife-Habitat Relationships (WHR) data base assists resource managers in evaluating effects of habitat manipulations on wildlife populations. However, the reliability of the WHR data base has been subjected to few field tests. We evaluated the accuracy of predictions made by WHR utilizing data from bird community surveys at Pinnacles National Monument during the winter and spring of 1984 and 1985. Using variable circular plots to compile species lists from the field, data were compared with species lists generated by WHR for vegetation habitat types in chamise-redshank chaparral, mixed chaparral, and valley-foothill hardwoods.

Two types of discrepancies were recognized: (i) "errors of commission" (species listed by WHR but not recorded in the field), and (ii) "errors of omission" (species recorded in the field but not listed by WHR). Valley-foothill hardwood had few errors of commission, but errors of omission averaged 22% in the winter and 19% in the spring. Errors of commission in the chaparral types ranged from 12% to 39%. In chamise chaparral, errors of omission ranged from 12% in the winter to 46% in the spring. The mixed chaparral error rates were 24% and 41%, respectively.

Additional effort should be directed toward field testing the predictive accuracy of the WHR data base. This is essential if WHR is to be used as an effective wildlife management tool.

INTRODUCTION

The California Wildlife-Habitat Relationships (WHR) Program was developed to create a standardized data base for wildlife species and their habitats (Grenfell et al. 1982). This WHR program is part of a multiagency national wildlife and fish habitat relationships program (Nelson and Salwasser 1982). The WHR data base is an information system that describes distribution, status, natural history, and habitat requirements of each terrestrial wildlife species. It is hoped that this information system will provide resource decision-makers and managers with current information about wildlife distributional patterns and capabilities of various habitats to support wildlife.

The usefulness of the WHR system is ultimately determined by how accurately it reflects events in the real world. The best way to evaluate the predictive accuracy of the California WHR system is by comparing its predictions to data collected in the field. In December 1983, we began a resource inventory at Pinnacles National Monument, San Benito County,

California. As part of that project we surveyed the avifauna throughout the Monument (Avery and van Riper 1986), and in this paper compare our findings to the bird communities predicted by the WHR system for chamise chaparral, mixed chaparral, and blue oak woodland.

METHODS

Pinnacles National Monument is located in the southern Gabilan Mountains, about 150 miles (240 km) south of San Francisco and 40 miles (64 km) east of Monterey, California. Over 80% of the 16,000 acre (6400 ha) park is covered by chaparral vegetation, with the remainder a mixture of foothill and riparian woodlands and bare rock (Webb 1969). There is a Mediterranean-type climate, with cool, wet winters and hot, dry summers. Precipitation averages 42 cm annually, with about 80% occurring during the December-March period.

Candidate sites at which to conduct bird surveys were selected using a 1:12,000 scale vegetation map prepared from aerial photographs taken in August 1983 (Figure 1). Criteria for candidate site selection included size of the stand (at least 5 ha), distance from the center to the edge of another habitat type (at least 75 m), and accessibility (relatively close to a marked trail). We purposely restricted our sites to those with no recent fire history in order to reduce variability due to plant age. Thus, all sites have been unburned for at least 30 yr. None of the sites has been grazed.

After inspecting candidate sites, we selected 33 permanent study plots among three habitat types:

1. Chamise chaparral (12 sites) is restricted to the dry south- and west-facing slopes throughout the Monument. Chamise (*Adenostema fasciculata*) accounts for most of the shrub cover, with buckbrush (*Ceanothus cuneatus*) and California buckwheat (*Eriogonum fasciculatum*) the only other shrubs of importance. Most sites had a sparse ground cover of annual grasses.

2. Mixed chaparral (7 sites), the most common vegetation type in the Monument, is dominated by chamise and buckbrush, but may include substantial components of manzanita (*Arctostaphylos glauca* and *A. pungens*), flowering ash (*Fraxinus dipetala*), scrub oak (*Quercus dumosa*), California buckwheat, and hollyleaf cherry (*Prunus ilicifolia*). This plant community occurs on north-facing slopes, and the ground cover includes annual grasses or ferns and various other shade-tolerant native species.

3. Blue oak (*Quercus douglasii*) woodland (14 sites) occurs on hillsides throughout the Monument and is variable in stand age and structure. The oaks may be interspersed with digger pine (*Pinus sabiana*) or California juniper (*Juniperus californica*). The understory component may include chamise, redberry (*Rhamnus crocea*), mountain mahogany (*Cercocarpus betuloides*), flowering ash, or buckbrush. The herbaceous ground cover is dominated by introduced annual grasses but also includes a rich mixture of native forbs.

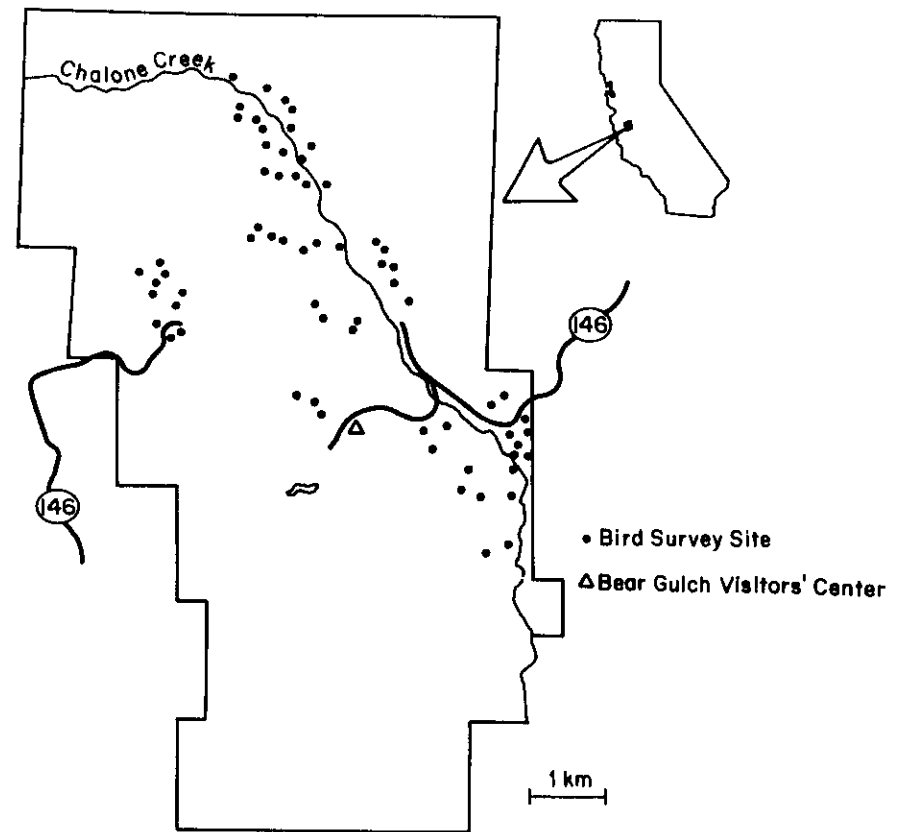## PINNACLES NATIONAL MONUMENT

FIGURE 1.   Map of Pinnacles National Monument, California, depicting locations of all permanently marked bird survey sites where censuses were performed.

Shrub and ground cover were measured at each chaparral site along a randomly placed 30-m transect. In addition, at 2-m intervals along the transect, a ruler was dropped vertically through the vegetation and the following data recorded: canopy height, points of contact of the ruler with live and dead vegetation, and litter depth.

In the oak woodland, sampling of vegetation cover was done by determining points of contact at 2-m intervals along 25-m transects extending from the center of each site in each of the four cardinal compass directions. Estimates of tree, shrub, and herbaceous cover were determined by averaging the percentages of contacts for the four transects.

We visited the 33 study sites three times during each of the following periods: 21 December 1983—22 February 1984, 2 April—5 June 1984, 23 November 1984—21 February 1985, and 2 April—27 June 1985. Bird counts were made using the variable circular plot technique (Reynolds et al. 1980). Field work was

scheduled so that no site was visited more than once every 2 weeks. Upon arriving at a site, 1 minute was allowed for the effects of the investigator's activity to abate. Then for the next 5 minutes, all birds seen or heard and the estimated distance from the observer were recorded. Counts started within 30 minutes of sunrise and were completed for the day within 3 hours. To minimize observer variability, one person (MLA) performed all bird counts. Common names of all birds mentioned in the paper, along with four-letter acronyms and scientific names, are included in Appendix 1.

In addition to an overall species list for each habitat type, we compiled a list of the most frequently detected species. Both lists were compared to the WHR printouts to evaluate the predictive success of the WHR models in both winter and spring.

Seven lists of species were obtained from the WHR system for San Benito County: chamise-red shank chaparral, age class 4 (senescent), canopy cover M (moderate) and D (dense); mixed chaparral, age class 4, canopy cover D; valley-foothill hardwood, size class 3 (pole-size trees), canopy covers P (open) and M (moderate); and valley-foothill hardwood, size class 4 (small trees), canopy covers M and D. Classification of the various study sites followed the WHR vegetation guidelines (Mayer and Laudenslayer 1988). Chaparral sites were grouped according to criteria developed by England (1988). Characteristics of the chaparral sites surveyed are given in Table 1.

In comparing the WHR printouts to the Pinnacles data set, we used only observations obtained during variable circular plot counts on our study sites. Furthermore, observations were limited to no more than 50 m distance to ensure that sampling occurred within the correct habitat type. Only species appropriately censused by the variable circular plot technique were used. Thus, hawks, owls, poorwills, herons, and egrets were excluded. Before making comparisons, we checked WHR printouts against species distribution maps (Grenfell and Laudenslayer 1983) to ensure that each species was in western San Benito County. This eliminated only a few species from the analysis.

Our primary concern was the first level predictions of presence or absence, with an emphasis on determining how well the WHR models predicted species composition of the bird communities at Pinnacles National Monument. To this end, omissions from the WHR lists of species found at the Monument are considered more serious than are the presence of species on the list that do not occur at Pinnacles.

In analyzing data, we first looked at the proportion of bird species recorded in the field that were predicted to occur by WHR. Observations made, but not predicted, provided a measure of "errors of omission." Species listed on the printout were compared to those recorded during the field surveys. The proportion not recorded in the field was the index for "errors of commission."

Recommendations for changes to the WHR data base are based on the relative abundance of the species in each habitat type. We recommended a species be added if we recorded it at least twice. We felt that a species should be deleted if we did not record it in the habitat type in question but did record it in other habitats.

TABLE 1. Vegetation Characteristics of Chaparral Sites Surveyed in Pinnacles National Monument During this Study. Totals are Means and Numbers in Parentheses are ± 1 S.D.

	% Total shrub cover	% Crown decadence	%Absolute cover	
			Adenostema	Ceanothus
Chamise Chaparral-4,M (senescent w/moderate canopy cover)				
Site 1	65.3	42.9	46.7	18.7
2	47.7	48.1	41.3	0
3	48.7	59.5	48.7	0
	53.9(±9.9)	50.2(±8.5)	45.6(±6.8)	6.2(±10.8)
Chamise Chaparral-4,D (senescent w/ dense canopy cover)				
Site 4	99.0	39.0	54.7	44.3
5	103.7	35.7	70.0	33.7
6	108.0	47.9	62.7	38.3
7	80.3	51.1	70.7	9.7
8	91.3	43.2	72.7	18.7
9	75.3	61.5	50.3	25.0
10	111.3	54.8	87.0	24.3
11	70.7	48.3	55.7	15.0
12	114.7	54.5	61.0	53.7
	94.9(±16.3)	48.4(±8.2)	65.0(±11.4)	29.2(±14.4)
Mixed Chaparral-4,D (senescent w/dense canopy cover)				
Site 13	91.7	42.2	0	42.7 [a]
14	111.7	43.5	0	61.0 [a]
15	91.3	42.4	0	0 [b]
16	123.7	38.3	0	34.0 [b]
17	90.7	59.5	22.7	11.3 [c]
18	136.7	46.3	42.7	94.0
19	126.0	40.7	11.0	40.3
	110.3(±19.2)	44.7(±7.0)	10.9(±16.5)	40.5(±31.2)

[a] *Quercus dumosa* was the other principal shrub species.
[b] *Fraxinus dipetela* and *Prunus ilicifolia* were the major shrub species.
[c] *Arctostaphylos glauca* was the most abundant shrub species.

RESULTS

The following is our interpretation of survey data compared to predictions from the WHR models. Habitat types serve as the main headings, and each includes short descriptions of our findings during "winter" and "spring" separately.

Chamise-Redshank Chaparral (senescent with moderate canopy cover; 3 sites)

Winter

We recorded 16 species, of which 14 (88%) were also predicted by the WHR data base (Table 2). Plain titmouse (our eighth most common species) and lesser goldfinch were missing species (Table 3). WHR listed 28 winter species, of which 14 were on our list. Of the 14 species not recorded, eight were attributed to insufficient sampling. However, we feel that the remaining six

TABLE 2. Summary of Comparison Between Field Observations and the WHR Predictions of Bird Species Composition in Various Habitat Types at Pinnacles National Monument, California.

Habitat type	Errors of omission				Errors of commission			
	Species found in the field		% not on WHR data base		Species on WHR data base		% not found in the field	
	W	S	W	S	W	S	W	S
Chamise Red-shank Chaparral (4,M), senescent, moderate canopy cover	16	20	12	30	28	32	21	22
Chamise Red-shank Chaparral (4,D), senescent, dense canopy cover	21	28	48	46	18	24	39	29
Mixed chaparral, senescent (4,D), dense canopy cover	17	27	24	41	28	32	25	12
Valley-Foothill Hardwood (3,P), pole-sized trees, open canopy cover	23	40	4	7	55	64	0	0
Valley-Foothill Hardwood (3,M), pole-sized trees, moderate canopy cover	24	39	21	13	43	50	7	0
Valley-Foothill Hardwood, (4,M), small trees, moderate canopy cover	22	31	18	6	46	54	6	2
Valley-Foothill Hardwood (4,D), small trees, dense canopy cover	23	36	48	50	32	35	12	0

W = Winter (December–February); S = Spring (March–June)

species (wild turkey, house wren, phainopepla, loggerhead shrike, European starling, and yellow-rumped warbler) were inappropriately included in this habitat type and should be deleted from the WHR data base (Table 4).

Spring

We recorded 20 species, 14 (70%) of which were also listed on WHR (Table 2). Two of the species omitted, plain titmouse and rufous-crowned sparrow, were among the birds that we most frequently recorded in this habitat and should be added to WHR (Table 3). The golden-crowned sparrow should also be added as it is common into late April even though it does not breed in the park. Of the 32 spring species on the WHR printout, we felt that all but seven were appropriate for the habitat. Questionable species were wild turkey, house wren, Swainson's thrush, phainopepla, loggerhead shrike, European starling, and Wilson's warbler; all should be deleted (Table 4).

Chamise-redshank Chaparral (senescent with dense canopy cover; 9 sites)
Winter

We recorded 21 species, 11 (52%) of which were also on the WHR list (Table 2). Species not listed included our second (plain titmouse) and tenth (brown towhee) most common species (Table 3). WHR listed 18 winter

TABLE 3. The Following Species Should be Added to the WHR Species List for the Seasons Indicated.

Chaparral		
Chamise red-shank, senescent, moderate canopy cover	Chamise red-shank, senescent, dense canopy cover	Mixed chaparral, senescent, dense canopy cover
PLTI (yl)	PLTI (yl)	PLTI (yl)
LEGO (yl)	LEGO (yl)	LEGO (yl)
GCSP (fs)	GCSP (fs)	GCSP (fs)
RCSP (yl)	BHGR (s)	
	CAQU (yl)	CAQU (yl)
	MODO (s)	
	NOFL (yl)	
		WEFL (s)
		WWPE (s)
		CNWR (yl)
	WEBL (s)	WEBL (yl)
	WCSP (fs)	WCSP (fs)
	BRTO (yl)	BRTO (yl)
	HETH (fs)	
	HUVI (fs)	
	VGSW (s)	

Valley-Foothill Hardwood			
Pole-sized trees, open canopy	Pole-sized trees, moderate canopy	Small trees, moderate canopy	Small trees, dense canopy
YRWA (fs)	YRWA (fs)		YRWA (fs)
			PUFI (yl)
			LEGO (yl)
		GCSP (fs)	GCSP (fs)
			CAQU (yl)
			MODO (s)
			VGSW (s)
	WEBL (yl)		WEBL (yl)
	BRTO (yl)	BRTO (yl)	BRTO (yl)
		CATH (l)	CATH (yl)
			WETA (s)
			ATFL (s)
			RCKI (fs)
			BGGN (s)
			WREN (yl)
			BEWR (yl)
			RSTO (yl)

yl = yearlong; fs = fall-spring; s = spring

species, of which we judged seven (wild turkey, white-throated swift, Nuttall's woodpecker, house wren, northern mockingbird, phainopepla, and yellow-rumped warbler) inappropriate for the habitat, and these should be deleted from WHR data base (Table 4).

Spring

We recorded 28 species, of which 15 (54%) were also on the WHR list (Table 2). Omitted species included our fourth (plain titmouse), ninth (lesser goldfinch), and tenth (brown towhee) most common species (Table 3). Of the 24 species listed by the WHR model, all were appropriate except the wild turkey, white-throated swift, nuttall's woodpecker, house wren, Swainson's thrush, northern mockingbird, and phainopepla (Table 4).

TABLE 4. The Following Should be Deleted from the WHR Species List for the Seasons Indicated.

Chaparral

Chamise red-shank, senescent, moderate canopy cover	Chamise red-shank, senescent, dense canopy cover	Mixed chaparral, senescent, dense canopy cover
WITU (yl)	WITU (yl)	WITU (yl)
PHAI (yl)	PHAI (yl)	PHAI (yl)
EUST (yl)		EUST (yl)
LOSH (w)		
SWTH (s)	SWTH (s)	SWTH (s)
HOWR (s)	HOWR (yl)	
YRWA (fs)	YRWA (fs)	YRWA (fs)
WIWA (s)		
		BTPI (yl)
		CEWA (yl)
		GCKI (w)
	WTSW (yl)	
	NOMO (yl)	
	NUWO (yl)	

Valley-Foothill Hardwood

Pole-sized trees, open canopy	Pole-sized trees, moderate canopy	Small trees, moderate canopy	Small trees, dense canopy
OCWA (w)	OCWA (w)	OCWA (w)	OCWA (w)
TOWA (w)	TOWA (w)	TOWA (w)	TOWA (w)
BHCO (w)	BHCO (w)	BHCO (w)	BHCO (w)
LASP (w)			
	SWTH (s)		
			HOWR (w)
WTSW (yl)	WTSW (yl)	WTSW (yl)	WTSW (yl)

yl = yearlong; w = winter; fs = fall-spring; s = spring

Mixed Chaparral (senescent with dense canopy cover; 7 sites)

Winter

There were 17 species on our winter list, and 13 (76%) were contained in the WHR database (Table 2). Species omitted included our fifth most commonly detected bird, the plain titmouse. Other omitted species were the California quail and golden-crowned sparrow (Table 3). The WHR model listed 28 winter species, 21 of which were either on our list or were considered appropriate species for the habitat. Seven remaining species were deemed inappropriate: wild turkey, band-tailed pigeon, golden-crowned kinglet, cedar waxwing, phainopepla, European starling, yellow-rumped warbler (Table 4).

Spring

Of 27 species, 16 (59%) were also on the WHR printout (Table 2). Two of our ten most common species (plain titmouse and lesser were omitted from WHR (Table 3). Only four of the 32 spring species on the WHR printout seemed inappropriate: wild turkey, Swainson's thrush, phainopepla, and European starling (Table 4).

Valley-Foothill Hardwood (pole-sized trees and open canopy; 4 sites)

Winter

We recorded 23 species, and all but one were predicted by the WHR data base (Table 2). The lone exception, the black phoebe, was detected only once. There were 55 species listed on the WHR printout, many of which do not occur at Pinnacles with sufficient frequency to be recorded during our counts (e.g.,

Lewis' woodpecker, yellow-billed magpie, cedar waxwing, loggerhead shrike), but which can be considered legitimate species in the habitat.

Spring

Of 40 recorded species, 37 (92.5%) were also on the WHR list (Table 2). Omissions included the yellow-rumped warbler, our eighth most frequently recorded species, and two species (purple finch and western tanager) recorded once each. Several species on the WHR list were observed only once in the field: Acorn woodpecker, blue-gray gnatcatcher, California quail, Lawrence's goldfinch, Steller's jay, and warbling vireo.

Unrecorded were 27 of the 64 species included on the WHR printout for the spring season. As in the winter, all missing species are reasonable for the habitat type.

Valley-Foothill Hardwood (pole-sized trees and moderate canopy cover; 4 sites)

Winter

In this habitat type, we recorded 24 species, 19 (79%) of which were also on the WHR printout (Table 2). Two of the missing species (golden-crowned and rufous-crowned sparrows) were recorded one time each. WHR listed 43 species, 40 of which were either on our list or appropriate for this habitat type. Three remaining species (orange-crowned warbler, Townsend's warbler, and brown-headed cowbird) were erroneously listed as occurring in the winter.

Spring

Of the 39 species on our list, 34 (87.2%) were listed on the WHR printout (Table 2). Of the five missing species, the lark sparrow and the California thrasher were each recorded only one time, but the western bluebird was among our 10 most frequently recorded species. All 50 species on the WHR list, were appropriate.

Valley-Foothill Hardwood (small trees with moderate canopy cover; 3 sites)

Winter

We recorded 22 species, and 18 (82%) were also on the WHR list (Table 2). Four omissions were the brown towhee (our fifth most common species); California thrasher (2 records); golden-crowned sparrow and canyon wren (one record each). All except the latter should be added to WHR (Table 3). WHR listed 46 winter species for this habitat. Only 18 of these match our list, while 18 others were recorded in oak woodland habitat sometime during the study period. However, in over two years of field work, we never recorded the following species in any of the oak woodland habitats: Lewis' woodpecker, yellow-billed magpie, common raven, golden-crowned kinglet, loggerhead shrike, American goldfinch, and house sparrow. All except the raven are rarely recorded in the Monument. The raven is a common species at Pinnacles, but evidently rarely uses the oak woodland habitat. The remaining three species should not be included in the WHR winter species list: orange-crowned warbler, Townsend's warbler, brown-headed cowbird.

Spring

Thirty-one species were recorded. Two of these were not on the WHR list: the brown towhee, our seventh most common species, and the western tanager, recorded once. There were 54 species on the WHR printout of which we recorded 29. Seven species are seldom, if ever, recorded at Pinnacles

National Monument, and 17 others were recorded in the habitat during the study but not during the actual count periods. The Swainson's thrush was found only in mixed riparian woodlands.

Valley-Foothill Hardwood (small trees with dense canopy cover; 3 sites)
Winter

There were 23 species on our list, but just 12 (52%) were included in the WHR database (Table 2). Omitted species were: Bewick's wren (our third most common species); rufous-sided towhee (fourth-ranked species); brown towhee (fifth-ranked species); California thrasher (our sixth most common species); western bluebird (the seventh-ranked species); golden-crowned sparrow, wrentit, ruby-crowned kinglet (two records each); California quail, fox sparrow, and lesser goldfinch (one record each). All of these species should be added to the WHR data base (Table 3). Of the 32 species on the WHR list, 12 were also on our list; 16 others were suitable for inclusion, but were too uncommon to be recorded during our counts. Four species do not belong: the white-throated swift is a cliff-nesting species that may occasionally fly over, but which is not a woodland species; orange-crowned and Townsend's warblers and brown-headed cowbird are not winter species at Pinnacles (Table 4).
Spring

As in the winter, there was poor agreement between our field observations and WHR data base predictions. Of 36 recorded species, only 18 (50%) were included in the WHR data base (Table 2). Among the missing species were our 3rd, 4th, 5th, and 6th most commonly observed species, respectively: Violet-green swallow, rufous-sided towhee, Bewick's wren, and western bluebird (Table 3). There were 35 species on the WHR list, and although we recorded only 18 during our surveys, the remaining are legitimate oak woodland species.

DISCUSSION

There are presently few published validations of California WHR habitat models. Verner (1980) and Dedon et al. (1986) tested mixed-conifer habitat types, mixed-evergreen was tested by Raphael and Marcot (1986), black oak (*O. kelloggii*) by Dedon et al. (1986), and chaparral by England and Anderson (1985). Results of these validation tests have been variable. In each instance the model predicted occurrence of species well, but the studies suggest that considerable revision will be necessary to improve performance in predicting relative abundances in habitat stages.

We believe that two simple indices can be used to assess the ability of the WHR data base to predict the presence of a species in a specific habitat type. The first presents the percentage of species recorded in the field but not included in the data base. The second measure is the percentage of species listed in the data base but not noted in the field. The first index measures the frequency of "errors of omission", species that should be on the data base but are not. The second is a measure of the "errors of commission", species that are incorrectly included in the data base. Errors of commission are to be expected, given that information in the data base was derived from various sources and studies at different locations and times. When compared to data from any given place and time, there is bound to be an excess of species. Increased sampling at more locations or over longer time periods will probably decrease the number of extra species and thereby lower the WHR errors of commission.

Errors of omission, on the other hand, reflect directly on the completeness of the data base and on its validity as a model of actual wild ife-habitat relationships. Given that we classified the habitat correctly and that the field data were reliably collected, a high frequency of missing species suggests either a lack of historical information in that habitat and/or location being considered, or a failure in the compilation of the existing WHR information. Neither option provides much consolation for a user who is trying to determine what species to expect in an area.

Our analysis revealed considerable variability among habitat types in errors of omission. Values ranged from 4% to 48% in the winter and 6% to 50% in the spring (Table 2). The best predictions occurred in the valley-foothill hardwood habitat for pole-sized trees with open and moderate canopy cover, and small trees with moderate canopy cover. These habitat types may be more widely studied or more common than the others that we tested, thus resulting in a more complete listing in the WHR data base.

The very poor predictive performance in the valley-foothill hardwood dense-canopied oak woodland may be due to the scarcity of this mature habitat, especially stands with a shrub understory. Several of the species found in this study, but not on the WHR data base, favor shrubs and brushy ground cover (e.g., California quail, California thrasher, Bewick's wren. wrentit, rufous-sided towhee, brown towhee, golden-crowned sparrow, and fox sparrow). Conceivably, most of the data in the WHR system are from studies in grazed oak woodlands where there is little or no understory. At Pinnacles, our study sites were virtually free from grazing pressure, and had healthy understory components. In this respect, the oak woodlands at Pinnacles National Monument may now be atypical, reflecting a woodland habitat structure that formerly was widespread in California but is no longer prevalent due to changing land use practices.

We found that chaparral communities were also characterized by relatively high rates of both types of errors (Table 2), as did England and Anderson (1985). This result is probably due to the lack of historical information on the bird communities in these habitat types. The published studies of chaparral birds with which we are familiar are all from southern California and none was conducted in mature, senescent stands of chaparral. Furthermore, most previous studies of chaparral birds have not considered the nonbreeding season. If the information in the WHR system was obtained from these sources, it is not surprising that there was poor agreement with field observations.

We recommend a number of additions to the WHR data base, particularly in the chamise and mixed chaparral and valley-foothill hardwood dense canopy habitat types (Table 3). These are based solely on field observations and represent a conservative list, in that we did not include species with just one record in a habitat type. Several species are recommended additions in three or more or the habitat types: Golden-crowned sparrow, brown towhee, lesser goldfinch, California quail, and western bluebird. These are all common species and, except for the golden-crowned sparrow, are yearlong residents in our study area.

The list of recommended deletions from the data base is small and is confined mainly to the chaparral habitat types (Table 4). Our justification for recommending the deletions in the chaparral habitats is that we did not record the

species in chaparral but did record them in other habitats within the study area. Although there were many species on the WHR data base for the valley-foothill hardwood habitats that we did not record in the field, there was no justification for deleting them as they undoubtedly use these habitat types elsewhere.

Overall, the analysis presented here was conservative. Had all of the species listed on the WHR printouts been included in the analysis, the errors of commission would have been much greater. Even so, there were still high errors of omission levels (greater than 20%) in five of the seven habitat types that we assessed. Similar results have been reported by others (England and Anderson 1985, Dedon et al. 1986, Raphael and Marcot 1986), using more detailed analyses. Together, these findings point to the need for further field evaluations and refinement of the WHR system. Moreover, potential users should be cautioned that, at present, the WHR data base may not adequately predict species composition for some locations and habitat types.

It seems imperative that the shortcomings in the WHR data base be identified as soon as possible, and that steps be taken to improve the predictive capability of the system. A first step might be to look at those habitat/location combinations for which published information is lacking. Such a situation certainly applies to mature chaparral. More may be known about birds in oak woodlands but, as mentioned previously, perhaps most studies in hardwoods have been conducted on rangeland with little or no shrub layer.

Some discrepancies are consequences of the species range maps. The violet-green swallow and chipping sparrow are each depicted with non-overlapping winter and spring ranges in San Benito County. Thus, these species are labeled yearlong in location even though at a given site within the county, Pinnacles for instance, the birds are present for just a portion of the year. The effect of inaccurate range maps leads to an increase in errors of commission. For the house wren, the eastern edge of San Benito County shows year-round residency, while 95% is summer only. The WHR printout gives yearlong as season in this location. The fox sparrow, golden-crowned sparrow, and white-crowned sparrow are shown as being winter (October–February) residents in San Benito County, even though they remain through April, at least at Pinnacles. This type of discrepancy incurs errors of omission when comparing the spring bird communities. The depicted ranges of the Townsend's solitaire and western tanager do not include San Benito County at all, yet both species do occur at Pinnacles, and the tanager is fairly common. Conversely, the yellow-bellied sapsucker and the mountain chickadee are on the printout even though their range maps do not include San Benito County. Townsend's warbler is shown as a winter resident, but occurs only in the spring and summer at Pinnacles.

Careful screening of all species range maps is time-consuming, but can help eliminate discrepancies such as those described above, and thereby reduce the error rate calculated for the system. Other reasons can be proposed for the lack of concordance between field observations and system predictions. For example, "The field study was not performed over a sufficiently long time span", or "The data available for incorporation into the system are not sufficiently complete to cover the field situation". However, regardless of their merit, reliance on *ad hoc* explanations to account for the shortcomings of the system is unprofitable, does not correct the identified problems, and will not convince others to use the product.

Our validation test of the California WHR species-habitat models suggests certain trends that future users should seriously consider. It appears that at a very gross level (e.g., predicting presence or absence) the WHR data base performs reasonably well in habitats that are well represented throughout the state. However, in those habitats that presently have a limited distribution (e.g., closed canopy oak woodland with understory) a number of inaccuracies appear. The chaparral habitats also performed poorly, indicating that the reliability of the WHR model may vary greatly among habitat types. Moreover, habitat suitability predictions seem to be generally poor. Therefore, potential users should be cognizant that gross level predictions are more reliable than are those dealing with minor habitat modifications.

Given the variable rates of agreement between predicted and observed community bird species lists in this study, and those reported elsewhere, it would be unwise to take a passive approach to validation of the California WHR system by waiting for interested parties to submit their field data and recommendations. Rather, an active approach is needed through which problem areas are identified and on-going research sought, or new studies initiated, to fill existing information gaps.

SUMMARY

Using data obtained during bird community surveys at Pinnacles National Monument in the winter and spring of 1984 and 1985, we evaluated the accuracy of predictions made by the California Wildlife-Habitat Relationships (WHR) data base. We used the variable circular plot technique to compile lists of species in the field, and compared these with species lists generated by the WHR system for habitat types in chamise-redshank chaparral, mixed chaparral, and valley-foothill hardwoods.

Two classes of discrepancies were recognized: (i) "errors of commission" (species listed by the data base but not recorded in the field), and (ii) "errors of omission" (species recorded in the field but not listed by the data base). The occurrence of errors of commission is not surprising given that the information in the data base was derived from various sources and studies at different locations and times. When compared with data from a given place and time, it is reasonable to expect an excess of species. On the other hand, errors of omission reflect directly on the completeness of the data base and on its validity as a model of actual wildlife-habitat relationships.

We found considerable variability among habitat types in both types of errors. The valley-foothill hardwood had few errors of commission, but errors of omission averaged 22% in the winter and 19% in the spring. Errors of commission in the chaparral habitat types ranged from 12% to 39%. Among the three chaparral types, errors of omission ranged from 12% to 48% in the winter and 30% to 46% in the spring.

In order for the WHR system to operate effectively, it must accurately predict the occurrence of species by habitat type, geographic location, and season. To date, the capability of the system to do this consistently has not been demonstrated. Our findings indicate that additional effort needs to be directed toward improving the accuracy of the first-level WHR models.

ACKNOWLEDGMENTS

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Editor's Note: The Wildlife Habitat Relationships data base, housed within the Department of Fish and Game, is an integral part of a dynamic system, the goal of which is to provide more effective tools for the management of wildlife in California. This data base is periodically updated in response to studies such as the one presented here and the ongoing efforts of the California Interagency Wildlife Task Group. Significant revisions of the avian models in the data base have been recently completed as have revisions of species distribution maps. Similar efforts for mammals, reptiles, and amphibians are currently underway.

APPENDIX I

Species Code, Common, and Scientific Names of Birds Mentioned in this Paper.

Species Code	Common Name	Scientific Name
ACWO	acorn woodpecker	Melanerpes formicivorus
AMGO	American goldfinch	Carduelis tristis
ATFL	ash-throated flycatcher	Myiarchus cinerascens
BEWR	Bewick's wren	Thryomanes bewickii
BGGN	blue-gray gnatcatcher	Polioptila caerulea
BHCO	brown-headed cowbird	Molothrus ater
BHGR	black-headed grosbeak	Pheucticus melanocephalus
BLPH	black phoebe	Sayornis nigricans
BRTO	brown towhee	Pipilo fuscans
BTPI	band-tailed pigeon	Columba fasciata
CATH	California thrasher	Toxostoma redivivum
CAQU	California quail	Callipepla californica
CEWA	cedar waxwing	Bombycilla cedrorum
CHSP	chipping sparrow	Spizella passerina
CNWR	canyon wren	Catherpes mexicanus
CORA	common raven	Corvus corax
EUST	European starling	Sturnus vulgaris
FOSP	fox sparrow	Passerella iliaca
GCKI	golden-crowned kinglet	Regulus satrapa
GCSP	golden-crowned sparrow	Zonotrichia atricapilla
HETH	hermit thrush	Catharus guttatus
HOSP	house sparrow	Passer domesticus
HOWR	house wren	Troglodytes aedon
HUVI	Hutton's vireo	Vireo huttoni
LAGO	Lawrence's goldfinch	Cardeulis lawrencei
LASP	lark sparrow	Chondestes grammacus
LEGO	lesser goldfinch	Carduelis psaltria
LEWO	Lewis' woodpecker	Melanerpes lewis
LOSH	loggerhead shrike	Lanius ludovicianus
MOCH	mountain chickadee	Parus gambeli
MODO	mourning dove	Zenaida macroura
NOFL	northern flicker	Colaptes auratus
NOMO	northern mockingbird	Mimus polyglottos
NUWO	Nuttall's woodpecker	Picoides nuttallii
OCWA	orange-crowned warbler	Vermivora celata
PHAI	phainopepla	Phainopepla nitens
PLTI	plain titmouse	Parus inornatus
PUFI	purple finch	Carpodacus purpureus
RCKI	ruby-crowned kinglet	Regulus calendula
RCSP	rufous-crowned sparrow	Aimophila ruficeps
RSTO	rufous-sided towhee	Pipilo erythrophthalmus
STJA	Steller's jay	Cyanocitta stelleri
SWTH	Swainson's thrush	Catharus ustulatus
TOSO	Townsend's solitaire	Myadestes townsendi
TOWA	Townsend's warbler	Dendroica townsendi
VGSW	violet-green swallow	Tachycineta thalassina
WAVI	warbling vireo	Vireo gilvus
WCSP	white-crowned sparrow	Zonotrichia leucophrys
WEBL	western bluebird	Sialia mexicana
WEFL	western flycatcher	Empidonax difficilis
WETA	western tanager	Piranga ludoviciana
WIWA	Wilson's warbler	Wilsonia pusilla
WITU	wild turkey	Meleagris gallopavo
WREN	wrentit	Chamaea fasciata
WTSW	white-throated swift	Aeronautes saxatalis
WWPE	western wood pewee	Contopus sordidulus
YBMA	yellow-billed magpie	Pica nuttalli
YBSA	yellow-bellied sapsucker	Sphyrapicus varius
YRWA	yellow-rumped warbler	Dendroica coronata